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Assessing the wind energy potential projects in Algeria

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ABSTRACT

A research program is under way in the SONELGAZ R&D Office with the aim of studying the potential of wind energy in Algeria. This paper presents an analysis of recently collected hourly wind data over a period of almost 5 years between 2002 and 2006, from four selected sites as well as preliminary evaluation of the wind energy potential. The results showed that Tindouf and Dély Brahim sites have higher wind energy potential with annual wind speed average of 5.8 and 5.7 m/s respectively at height of 17 m above ground level (AGL). The two sites are candidates for remote area wind energy applications. The Ouled Fayet and Marsa Ben M'hidi sites wind speed data indicated that the two sites have lower annual wind speed averages between 3.9–4.7 m/s at 17 m AGL. That makes the two sites candidates for installation of windmills to provide water for drinking and small scale irrigation purposes Brief description of the equipment, is also performed. Finally the aim of this work is only a preliminary study in order to assess wind energy analysis in Algeria and give useful insights to engineers and experts dealing with wind energy.

Contents

1. Introduction

Utilization of non-renewable energy sources not only results in environmental deterioration but also confronts us with the dilemma of a rapid rate of depletion of such resources, while renewable energy sources can serve us indefinitely with minimal environmental impacts as compared with fossil fuels. The renewable energy projects are tools for the management of reserves and sustainable development of desert communities. These are generally areas where a diesel or gas-powered generator presents a problem of fuel transportation and many potentially harm the environment [1]. Tremendous opportunities exist in Algeria for growth in the use of renewable energy technologies. From 1999 up 2004 the Societé Nationale de l'Electricité et du Gaz SONELGAZ R&D office Renewable Energy Program and the Ministère de l'Energie et des mines (MEM) have collaborated and sponsored several photovoltaic projects in 20 villages of the desert of Algeria aiming at increasing the use of

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renewable energy technologies, thus providing green power to isolated villages [2]. SONELGAZ's role in the project is to initiate renewable energy pilot projects that could be easily replicated by area residents and provide training with technical assistance [3].

In fact, at present, the CREDEG is leading the way towards the development and utilization renewable sources of energy in the country in general and wind energy in particular. It planned and implemented its wind energy project. Recently, work on analysis of wind speed data such as Determination of price and wind speed for hybrid power system feasibility, Renewable energy resource assessment, Weibull parameters resolution and distribution, etc., has been reported in the literature.

Himri et al. [4] conducted a study to perform an economical feasibility of an existing grid connected diesel power plant supplying energy to a remotely located by adding wind turbine/s in the existing power system in order to reduce the diesel consumption and environmental pollution, using HOMER simulation model. They found that the wind diesel hybrid system becomes feasible at a wind speed of 5.48 m/s or more and a fuel price of US$ 0.162/L or more.

In another study, Himri et al. [5] presented a review and the use of the Algerian renewable energy for sustainable development and they discussed about the analysis of the present renewable energy situation and future objective. Himri et al. [6] computed Weibull parameters for wind speed distribution at fifteen locations in Algeria. The wind data which covers a period of almost 10 years between 1977 and 1988 was adopted. The average wind speed at a height of 10 m above ground level was found to range from 2.3 to 5.9 m/s. The Weibull distributions parameters (c and k) were found to vary between 3.1 and 7.2 m/s and 1.19 to 2.15, respectively. The two parameters of a Weibull density distribution function for the three areas namely (Littoral, Highlands and Sahara) were compared and wider distributions were observed in the Sahara. It is noticed also that the Weibull distribution give a good fit to experimental data.

The present study reports recently collected wind data analysis at four locations namely Tindouf, Dély Brahim, Ouled Fayet and Marsa Ben M'hidi in Algeria. The main objective of this study is to quantify the wind power potential in these four locations. Hourly wind data, which were observed over a period almost 05 years gathered between the years 2001 and 2006, were clustered in 12 directional sectors; each one extended over 30° according to the direction from which the wind blows. The means values, wind speeds, wind potential, the dominant wind directions and the Weibull parameters were calculated using WAsP software (the Wind Atlas Analysis and Application Program).

2. Data processing

Wind data used in this paper were taken from SONELGAZ R&D Office [7]. Hourly wind data which cover a period of 04 to 05 years (between 2001 and 2006) are used at 04 sites in Algeria. The wind speed measurements were made at an elevation of 17 m above the ground level. The geographical locations of the automatic climatological recording stations (Thies, Germany) are summarized in Table 1. The data logger was powered by a 12 V battery. For data transmission a memory card (storage capacity of 40 days) was used.

The Data Acquisition Systems was programmed to an averaging interval of 10 min. A schematic diagram showing the positions of all the sensors on the mast is shown in Fig. 1.

The atmospheric air temperature (°C), relative humidity (%), pressure (mm of Hg) and global solar radiation (W/m^2) data were collected at approximately 2 m above the ground level.

Table 1
The geographical locations of the automatic climatological recording stations (Thies, Germany).

Location	Latitude (°)	Longitude (°)	Altitude (m)	Duration (years)	Measurement years
Timimoun	29°15′N	00°17′E	312	04	2001–2004
Tindouf	27°40′N	08°06′W	401	05	2002–2006
Dély Brahim	36°74′N	02°97′E	215	04	2003–2006
Ouled Fayet	36°73′N	02°97′E	255	05	2002–2006

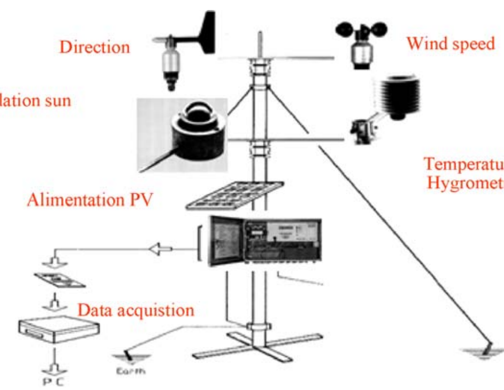


Fig. 1. Schematic diagram of automatic climatological recording stations (Thies, Germany) installed in the fourth sites.

3. Analyses, results and discussions

In this study the wind speed measurements data for 04 locations in Algeria for a period of 4–5 years have been analyzed using WAsP program. Computation were then made to get mean wind speed, mean wind power density, the Weibull distribution parameters in terms of k and c and direction. The main results obtained from the present study can be summarized as follows.

4. Mean wind speed

Wind speed is the most important aspect of the wind resource; in fact the yearly variation of long term mean wind speed provides an understanding of the long term pattern of wind speed and also gives confidence to an investor on the availability of wind power in coming years.

Fig. 2 provides the variation of long-term mean wind speed during entire data collection period at 04 stations under consideration in this study.

It is seen from Fig. 2 that Tindouf has the maximum mean wind speed of 5.8 m/s while Marsa Ben M'hidi has the minimum wind speed of 3.9 m/s. It is also noticed that the southern region such as Tindouf has higher mean wind speeds compared to the northern regions like Dély Brahim, Ouled Fayet and Marsa Ben M'hidi. It is also observed that Dély Brahim has the highest mean wind speed of 5.7 m/s compared to the northern region (Ouled Fayet and Marsa Ben M'hidi).

Among annual averages, Tindouf and Dély Brahim show higher value of wind speed, and thus can be rated a better choice for wind energy utilization in comparison to other coastal sites such as Ouled Fayet and Marsa Ben M'hidi. Although these later could be developed for an inexpensive low speed (lower than 4.4 m/s) windmills to provide water for drinking and small scale irrigation purposes.

5. Mean wind power density

Wind power density expressed in Watt per meter square (W/m^2), takes the frequency distribution of the wind speed, the wind

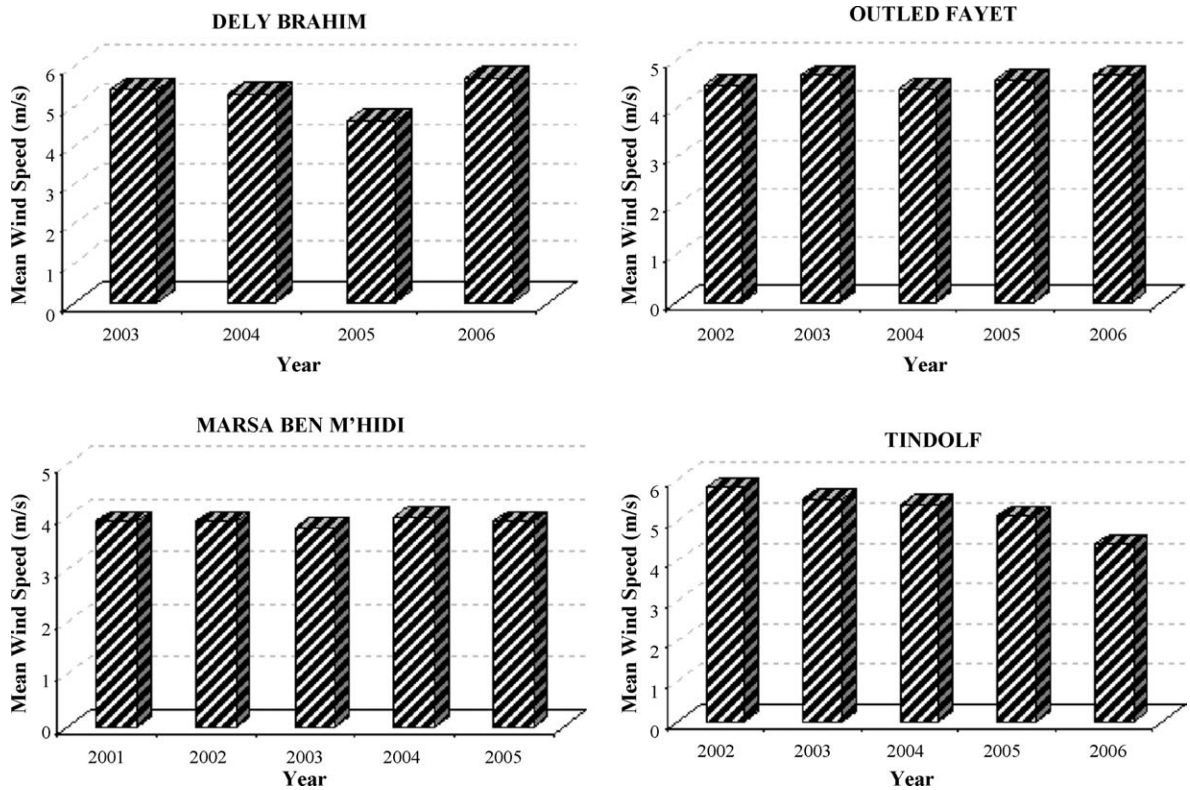


Fig. 2. Annual variation of mean wind speed for four locations at 17 m above ground level.

density and the cube of the wind speed into account. Consequently, wind power density is considered to be the best indicator to determine the potential wind resource, which is critical to all aspects of wind energy exploitation, from the identification of suitable sites and predictions of the economic viability of wind farm projects through to the design of wind turbines themselves. The results of the annually mean wind power density at 04 Meteorological Stations are presented in Fig. 3. As seen from Fig. 3,

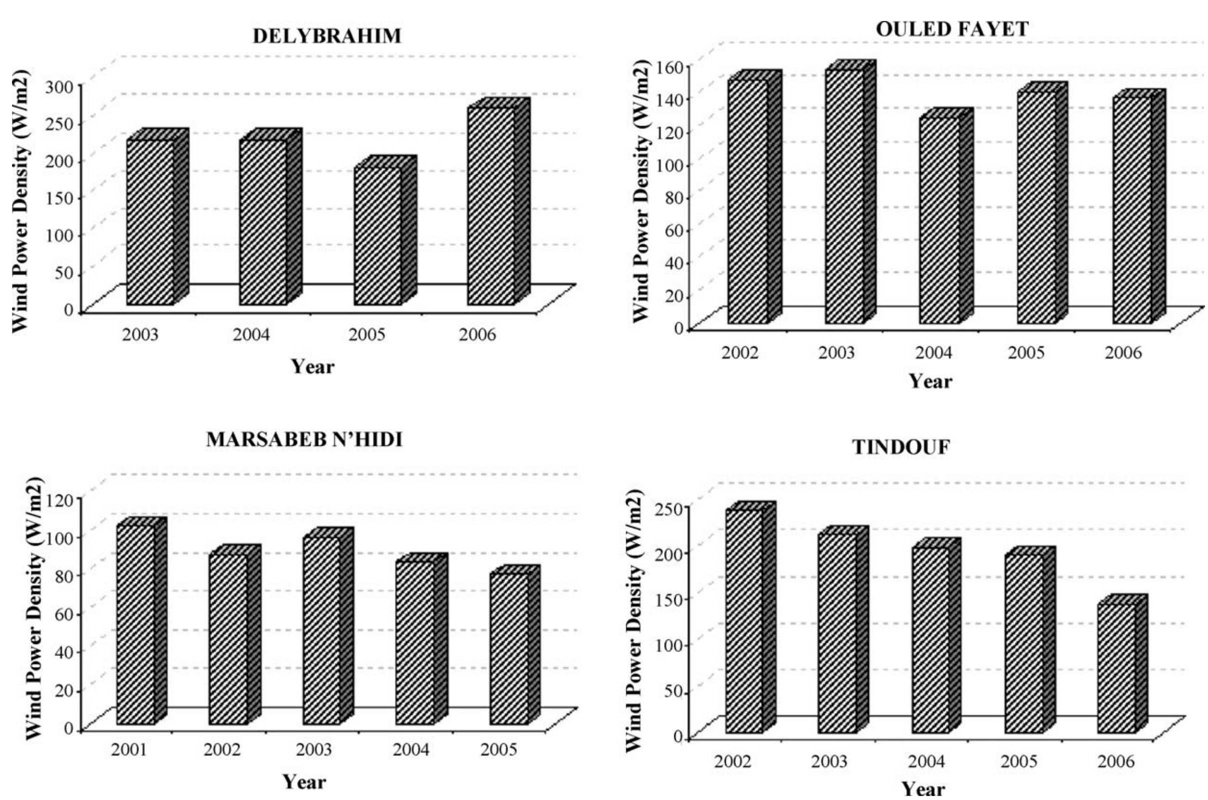


Fig. 3. Annual mean wind power density for four locations at 17 m above ground level.

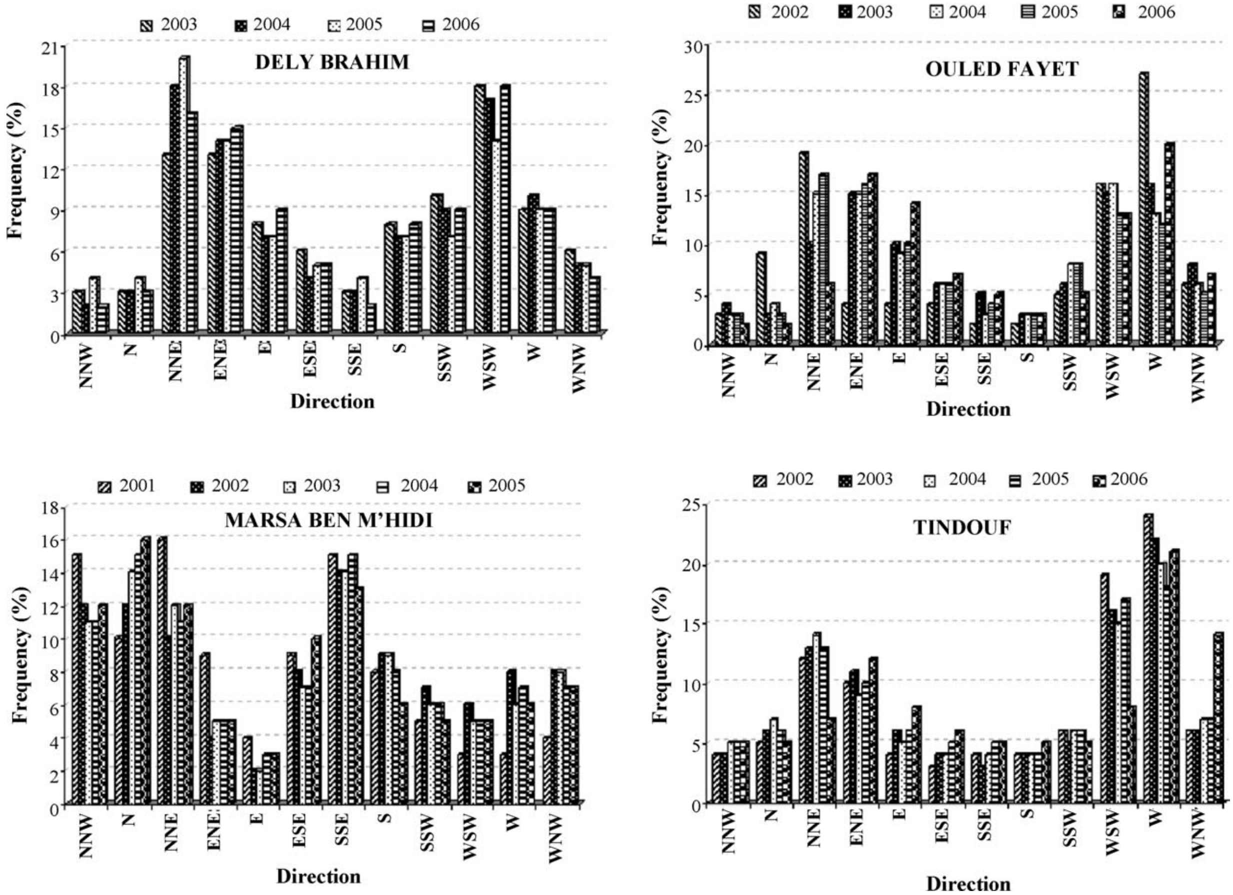


Fig. 4. Dominant wind speed directions for four locations at 17 m above ground level.

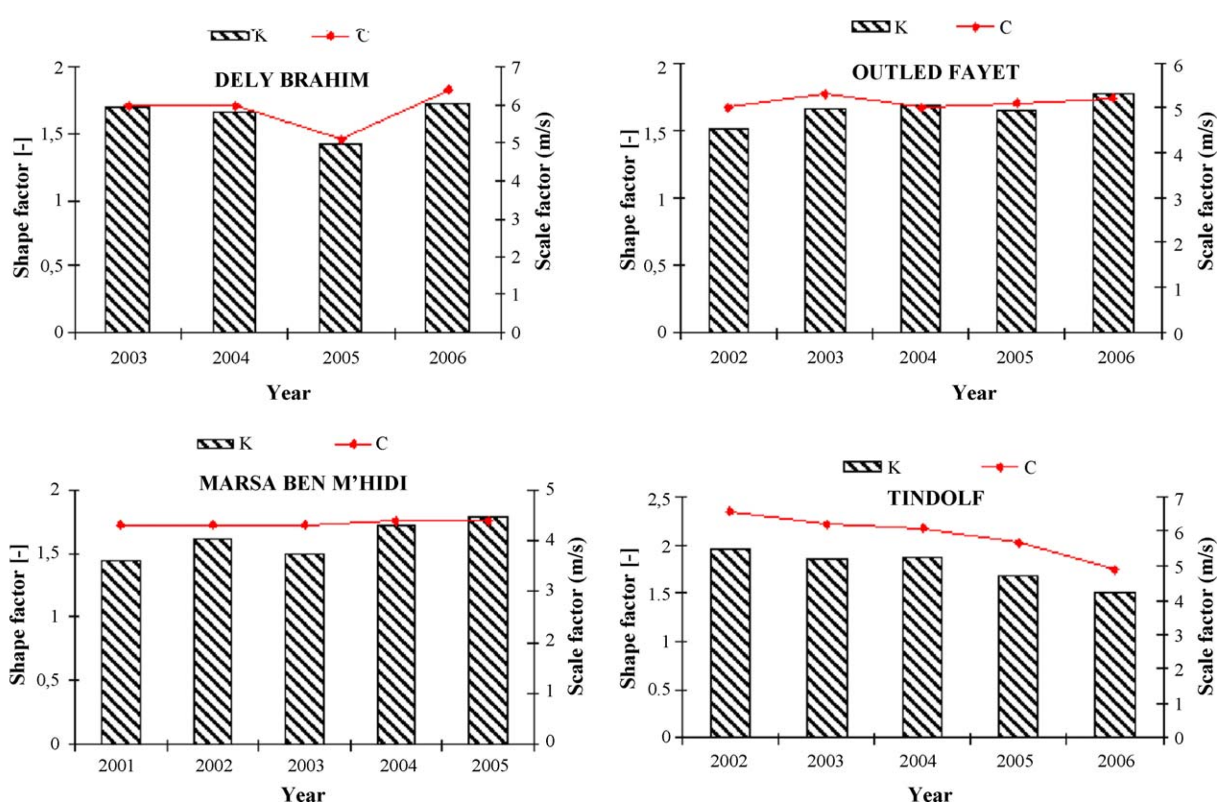


Fig. 5. Weibull distribution parameters for four locations 17 m above ground level.

Dély Brahim has the highest annual mean power density with a value of 259 W/m^2 while Marsa Ben M'hidi has the lowest with 77 W/m^2. For Tindouf the yearly mean wind power density varies from 138 W/m^2 in 2006 to 238 W/m^2 in 2002. It is obvious that both Dély Brahim and Tindouf have good wind potential that can be exploited.

6. Wind direction

The wind direction is of decisive important for the possibilities assessment of using wind energy. The direction statistics play a significance role in the optimal positioning of a wind farm in a given area. The wind speed data of this station were grouped into twelve directional sectors: North-North West (NNW), North (N), North-North East (NNE), East-North East (ENE), East (E), East-South East (ESE), South-South East (SSE), South (S), South-South West (SSW), West-South West (WSW), West (W), and West-North West (WNW).

So, each one extended over 30° according to the direction from which the wind blows. The dominant prevailing wind directions for each station are presented in Fig. 4.

According to this Figure, the dominant prevailing wind directions for Tindouf and Ouled Fayet meteorological stations are (W, WSW), on the other hand for Dély Brahim and Marsa Ben M'hidi are (WSW, NNE) and (SSE, NNW), respectively.

7. Weibull distribution function

To describe the probability distribution of wind speed, the Weibull function has been extensively used in wind resource assessment. The wind speed data is obtained from SONELGAZ R&D Office (2007) [7]. As noticed from the Weibull parameters, namely, shape parameter k (dimensionless) and scale parameter c (m/s) are computed for all 04 locations in Algeria based on annual average wind speed.

As shown from Fig. 5, it is apparent that for Tindouf, Ouled Fayet, Dély Brahim and Marsa Ben M'hidi the shape factor k does not remain stable through out the years. For Tindouf, the minimum k is 1.52 in the year of 2006 and maximum value is 1.95 for 2002. For Ouled Fayet the minimum is 1.51 in 2002 and the maximum is 1.77 in 2006.

Dély Brahim minimum is 1.42 in 2005 and maximum is 1.73 in 2006 while for Marsa Ben M'hidi the minimum k is 1.44 in 2001 and maximum is 1.79 in 2005. For the scale parameter c, highest values, i.e. greater than 4.8 were found at Tindouf, Dély Brahim and Ouled Fayet whiles the lowest (lower than 4.8) at Marsa Ben M'hidi West area of the country. It is clear that the parameter k has a much smaller variation than the parameter c. In general, the values of Weibull parameters are high in Tindouf and low at the rest part of the country Dély Brahim, Ouled Fayet and Marsa Ben M'hidi.

8. Conclusion

In this study evaluation if wind potential in Algeria. It is hoped the work will be useful for studying the effectiveness of wind turbines for water pumping and also will provide a strong base for assessing the feasibility of applying large wind turbines to generate electricity.

The site of Tindouf has the highest wind energy potential compared to the other sites with annual wind speed average of 5.8 m/s. The site of Dély Brahim is the second in wind energy potential with annual average wind speed of 5.7 m/s. At the Northern region sites namely, Ouled Fayet and Marsa Ben M'hidi, the wind blows at speed lower that 5 m/s. Overall the yearly wind speed and the average wind power densities are in the range of 3.9 to 5.8 m/s and 77 to 259 W/m^2 with a steady trend over the period from 2001 to 2006. This is a very good feature in the application of wind as windmills and wind machines at a small scale for rural areas. In addition to wind resource evaluation, information from the database will be useful to various governmental and private entities.

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